Letters

Oliver Heaviside

Dear Sir — Oliver Heaviside, who was born in London on the 13th May 1850 and died at Torquay on the 3rd February 1925, was an outstanding pioneer in the field of electrical engineering. For the purpose of this letter reference is made only to the following of his many achievements:

- He developed the method of vector analysis and started to use it exclusively for Maxwell's equations in 1882, whereas Maxwell, in his 'Treatise on electricity and magnetism', used quaternions for the field quantities. Heaviside expounded Maxwell's theory in detail and in very clear, systematic terms, virtually in the form which has since become classical.
- He established the concept of the energy-flow vector (i.e. Poynting vector) independently of, and in more detail than did, Prof. Poynting. Also, he used vector notation for his proof as we use it today, whereas Poynting used quaternions.
- He produced — against bitter opposition — practically the entire transmission-line theory as we know it today. In this connection, he also coined the now commonly used terms capacitance, inductance, reactance, as well as many others.

Oliver Heaviside was a great scientist, and we consider that his name should be more adequately honoured, as two of us have already pointed out elsewhere.[1,2] Referring to the above-mentioned achievements, we would suggest the following modifications in the existing terminology:

- 'Maxwell-Heaviside equations' instead of just 'Maxwell's equations'
- 'Poynting-Heaviside vector' instead of just 'Poynting vector'
- 'Heaviside equations' instead of the currently nameless 'transmission-line equations'.

We herewith submit our proposal to our colleagues with an invitation to give it their support. Those who work in the field of education and those who are authors of books and papers could be especially helpful. By establishing the usage of the proposed terms it will eventually become possible to meet the rules of the International Electrotechnical Commission (IEC) and to incorporate them in the IEC's International Electrotechnical Vocabulary. — Yours faithfully,

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9th November 1976

References
1 UNZ, H.: 'Oliver Heaviside (1850-1925)', *IEEE Trans.*, **E-6**, 1963, pp.30-33
2 MERCER, D. M. A.: 'Rewards that came too late', Broadcast on BBC, 22nd January and 2nd March, 1976

Better than battery?

Dear Sir — With reference to the letter by J. McCool (October 1976 *E & P*, p. 705) regarding bicycles and battery-powered vehicles, he does not mention three significant disadvantages of the conventional bicycle:

- no protection from the weather
- poor stability on slippery surfaces
- not apparently visible to other road users

Taking these points in order, the heavy rain we have experienced recently in Britain soon gets through, around or under any of the protective clothing normally worn by cyclists, particularly if there is a strong wind blowing.

If a 3- or 4-wheeled vehicle skids on a slippery surface, the driver frequently has time to take corrective action, so that the vehicle recovers and the journey can be continued as if nothing had happened. On a 2-wheeled vehicle, however, considerable skill is required to correct even a rear-wheel skid, a front-wheel skid usually resulting in the rider falling off, possibly into the path of another vehicle. Bicycles are smaller, and therefore less visible, than most other vehicles. Consequently they are frequently overlooked by other road users, who also take advantage of the narrowness of the bicycle to overtake when there is not sufficient room. I personally find it a harrowing experience to be overtaken by a large articulated vehicle which passes within inches of the end of my handlebars.

In my view, the above factors significantly reduce the popularity of the bicycle for personal transport. However, it is pertinent to raise the question, as J. McCool has done, as to whether the battery-powered vehicle is the best alternative to the conventional motor car for short journeys.

Some time ago, I attempted to design a 'better bicycle' which would overcome some of the disadvantages of the conventional machine. The resulting design looked like a cross between an old-fashioned invalid carriage and a drag racer. The proposed vehicle was, in fact, a tricycle with two large wheels at the rear and a small wheel at the front for steering. The rider was to be seated low down between the rear wheels and totally enclosed by light bodywork. Each rear wheel was to be driven independently via a 'free wheel' connected by a flexible steel cable to a foot pedal. This removed the need for a differential in the back axle and would also allow the rider to push with both feet when starting on particularly steep hills (or gentle hills when feeling tired?)

However, as is usual with such projects, lack of time has prevented me from taking the design any further. Perhaps this letter will provide inspiration for someone. — Yours faithfully,

D. SHARP (M)
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Sharpthorne, East Grinstead
Sussex RH19 4NY, England
6th November 1976

Examination question

Dear Sir — In CEI Paper 342 'Electromechanical energy conversion', questions appear from time to time on synchronous machines in which the field current is required. The information given is the unsaturated d-axis and q-axis synchronous reactances and the open-circuit magnetisation curve for a specified load. The required method is shown in Example 6 of the Study Guide.

The difficulty lies in allowing for saturation by taking the difference between the airgap line and the open-circuit curve at a point corresponding to the rated voltage V. It is well known that the difference should be taken at a point corresponding to the e.m.f. E, if this were known. The problem in the Study Guide has the atypical condition of a motor running at 0·95 lagging power factor and the difference between V and E would be negligible. In problem 4 of the 1971 paper and problem 7 of the 1975 paper this is not so; the former is a motor with 0·9 leading power factor and the latter a generator with 0·8 lagging power factor. Such conditions are discussed in the Study Guide, but necessarily in general terms because the value of the leakage reactance is unknown; it might have any value from 5 to 30%.

My complaint is that the standard form of question (which goes back to the days of the IEE Part 3 examination) should not be set because it gives impractical results. The following figures give a comparison between the Study Guide method, the answer resulting from converting the data into the simple ampere-turn method (recognised as underestimating the field current) and the answer if 20% leakage reactance is assumed.

Yours faithfully,

R. BOURNE
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10th November 1976

	Study-guide method	Simple ampere-turn method	Method allowing 20% X_l
Study guide No. 6	10·4A(100%)	10·1A(97%)	10·3A(99%)
1971 Examination No. 4	55A (100%)	60A (109%)	60·5A(110%)
1975 Examination No. 7	66·5A(100%)	67A (101%)	74·5A(112%)

Dear Sir — In agreeing with J. McCool, may I suggest that he also considers the horse? Although it is dangerous at both ends and uncomfortable in the middle, it does have two great advantages: (*a*) it can be programmed to follow a set pattern (e.g. a milk round) without guidance, and (*b*) if fuel is inserted at one end a useful by-product is obtained from the other. — Yours faithfully,

J. C. TURNBULL (F)
Rosegarth, Great Broughton
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28th October 1976

Letters

Examination question

Dear Sir — As author of the Study Guide for the CEI Paper 342 on Electromechanical energy conversion referred to by R. Bourne (Feb. 1977 *E & P*, p.115), I am grateful to him for raising the question of allowing for saturation in estimating the field current of a loaded synchronous machine; it appears that a number of teachers are unfamiliar with the flux conditons in such a machine and often present solutions that are absurd.

Mr. Bourne states that the 'required' method is that shown in the Study Guide; this method is, however, by no means 'required', as several alternatives are available from which the student or teacher can choose at will. The method given, however, is simple and brings out clearly the significance of saturation; furthermore it is reasonably accurate provided, as stated in the Guide, that it is modified by allowing for an estimated value of leakage reactance, this being, in practice, usually unknown and not readily available from simple tests.

I do not agree with Mr. Bourne that such questions, involving an estimation based on brief experience and which can thus have only an approximate solution, should not be set. They represent a practical problem, and students should surely have been led, by laboratory experiments, to appreciate the difficulty of *accurately* predicting the behaviour of such a complex device as a synchronous machine — Yours faithfully,

E. O. TAYLOR (F)
Clare Cottage, Pett Road
Guestling, East Sussex, England
11th March 1977

Electric cars

Dear Sir — There seems to be a widespread belief that the use of an electric drive automatically removes the need for a gearbox in a car; but I believe this is erroneous. In railway traction, the thermal inertia of the motors is usually so large that they are provided with a half-hour rating as well as a continuous rating. In these circumstances, the maximum current through the armature windings can be temporarily increased when a large starting torque is required. But the driver of a road vehicle expects to be able to use maximum power at low speed for an unlimited time, e.g. when gaining height of 1000 m or more over a mountain pass.

Your recent article on 'Some hybrid propulsion systems for electric vehicles' (Feb. 1977 *E & P*, p.125) mentions the use of an induction motor with variable-frequency supply, and it is sometimes suggested that the supply voltage should be varied with the frequency so as to produce a constant-torque characteristic at varying speed. An approach to this may be desirable in any case since the torque of an induction motor depends on slip, and efficiency requires that slip be kept fairly small; but this means that, by varying speed at constant torque, one could climb a steep hill at maximum speed (not quite because it is assumed that at maximum speed the power will be dissipated in dealing with rolling resistance and air resistance).

A road vehicle needs to be able to generate maximum power at low road speeds in order to climb hills. Usually the engine is continuously rated for operation in such conditions, and some kind of torque convertor or gear box is used to enable maximum power to correspond to maximum torque at a fairly high engine speed but actual drive to the road wheels to be at a much less speed and therefore greater torque. I do not know of any device for achieving the same end electrically, since torque is proportional to the product of magnetic field and current density (both of which are subject to limits) and power then depends on speed times torque. I know that this view is highly heretical, but it seems to me logical that an electric car must have a gear box. — Yours faithfully,

D. A. BELL (F)
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1st March 1977

Energy matters

Dear Sir – R. A. Keall (Jan. 1977 *E&P*, p.23) is correct in his calculations of the potential thermodynamic efficiency of various systems. However, I submit that the Second Law can only be invoked when thermal energy is the penultimate product, for instance in a power station. In domestic heating, where thermal energy is the final product, a simple energy-in to heat-out calculation is all that is required to find the efficiency of a system. – Yours faithfully,

D. J. PRICE
Beechcroft, Old London Road
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England
17th February 1977

Final demand

Dear Sir — When reading in 'Focus' (Jan. 1977 *E & P*, p.13) of the constant demand for well qualified engineers which is not met, I could hardly believe my eyes.

As soon as Britain's ambitious school population learn of the wealth, or fame, or dignity, or whatever, which will come to them when they are well qualified engineers, then there will *surely* be no shortage.

You can't keep a good man down, you know, but you can easily keep him out of engineering, and mathematics and physics no doubt. — Yours faithfully,

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23rd February 1977

Oliver Heaviside

Dear Sir — I agree totally with your correspondents Unz, Mercer and Feinberg regarding the achievements of Oliver Heaviside (Feb. 1977 *E & P*, p.115). Having read Heaviside's three volumes, plus more background material, I would say that he should be ranked alongside Faraday as the two greatest pioneers of electrical engineering ever known.

It should be placed on record that the subject of electromagnetic field theory would be greatly advanced by all interested individuals if they read Oliver Heaviside's work. Although it is 70 years too late, we should now attempt to redress the balance and pay tribute to this great man's achievements.

If we are to advance at all it is imperative that we first look back and check our foundations to see that they are solid, or not, as the case may be. I think electrical engineers everywhere might have quite a surprise if they did stop and look backwards at the base of the subject of e.m. theory. – Yours faithfully,

M. F. DAVIDSON (AM)
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Herts., England
27th February 1977

Dear Sir — While it is true that Heaviside extracted and developed vector analysis from the earlier theory of quaternions of Hamilton, it should also be observed that, in doing so, he performed a classical 'baby and bathwater' experiment. The voluminous correspondence of the times[1] need not be recapitulated, but the consequences which are now becoming apparent should be noted:

- By categorically refuting the need for a scalar component, he delayed the recognition of the vital part space-time was eventually to play.
- In doing so, he isolated the engineering and technological aspects of vector analysis from the main stream of theoretical physics and abstract algebra leading to the two-cultures system which exists to this day.
- In consequence, the development and applications of the theory of groups (Hamilton's greatest discovery!) to physics generally and engineering particularly is about a generation late.

Regarding the Poynting vector, Hamilton derived it as a first consequence of his quaternion theory in 1843,[2] where he talks of 'a glimpse of a future calculus of polarities'. In fact quaternions are almost forced on one if one studies polarisation and spin.

In its simplest terms everything that can be described by vector methods can be so also by quaternion methods, but the latter can also describe *and derive* results that vector methods alone cannot.[3]

On the purely didactic side, the idea of perpetuating a name by associating equations with their discoverers is not itself very satisfactory, for example the WJKB approximation. Maxwell's equations is also a rare example of invariance under the transformation English → Russian. We may only end up with the GHMHG* equations. — Yours faithfully,

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1st March 1977

*Gauss-Hamilton-Maxwell-Heaviside-Gibbs**
**or Green

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